Div VII & IX

HISTORY OF THE STANDARD WEIGHTS AND MEASURES OF THE UNITED STATES.[a]

By Louis A. Fischer.

The subject of weights and measures is one of such great interest and importance and is attracting so much attention in this country and in England at the present time that a short account of the steps taken to secure uniformity in the United States is deemed an appropriate subject to bring to the attention of this convention.

The attention of the United States Government has long been directed toward securing uniformity in this country, and in the effort to secure international agreement in weights and measures it has always shown the greatest interest. The history of the original Confederation of States and of the constitutional government of the United States is full of evidences of the perplexities arising from the diversity of weights and measures throughout their jurisdiction and of the desirability of a uniform system.

The weights and measures in common use in this country at the time of the American Revolution were all of English origin and were in use in England at that period. The principal units were the yard, the avoirdupois pound, the gallon, and the bushel. More or less authentic copies of the English standards of the denominations mentioned had been brought over from time to time and adopted by the different colonies. Divergencies in these weights and measures were, however, quite common, due no doubt to the fact that the system of weights and measures of England was not itself well established, and hence the copies brought to this country were often adjusted to different standards.

That this condition was recognized very early is made evident by the Articles of Confederation which contained the following clause: "The

[a] An address delivered before the First Annual Meeting of the Sealers of Weights and Measures of the United States at the Bureau of Standards, Washington, D. C., 1905.

United States in Congress assembled shall also have the sole and exclusive right and power of regulating the alloy and value of coin struck by their own authority, or by that of the respective States—fixing the standard of weights and measures throughout the United States." This power was transferred to Congress by the Constitution of the United States in article 1, section 8, the language being as follows: "The Congress shall have Power . . . To coin Money, regulate the Value thereof, and of foreign Coin, and fix the Standard of Weights and Measures;".

While Congress was not slow to take action in regard to coinage, it seems not to have been inclined to come to a decision in regard to weights and measures, though apparently willing enough to consider the subject. Washington, in his first annual message to Congress, January, 1790,[a] stated that "uniformity in the currency, weights, and measures of the United States is an object of great importance, and will, I am persuaded, be duly attended to." In accordance with Washington's suggestion, the matter was referred to a select committee of the House of Representatives with instructions to prepare a bill, and it was also ordered that the matter be referred to the Secretary of State to prepare and report to the House a proper plan for establishing uniformity in the weights and measures.[b] Jefferson was then Secretary of State, and in response to the above request made a report, in which he proposed two distinct plans. The first was substantially to "define and render uniform and stable the existing system * * * to reduce the dry and liquid measures to corresponding capacities by establishing a single gallon of 270 cubic inches and a bushel of eight gallons, or 2,160 cubic inches * * *." The second plan was "to reduce every branch to the same decimal ratio already established for coin, and thus bring the calculations of the principal affairs of life within the arithmetic of every man who can multiply and divide plain numbers."[c]

No action was taken, however, by the House and in his second message to Congress, on December 8, 1790, Washington again called the attention of that body to the importance of the subject.[d] A few days later the House ordered that the report of Jefferson, referred to above, be communicated to the Senate. On March 1, 1791, the Senate committee to which the matter had been referred reported that it would not be eligible to make a change in the weights and measures, as a

[a] Messages and Papers of the Presidents, **1**, p. 66.
[b] Congressional Register, **3**, p. 106.
[c] Journal of the H. R., Childs & Swaine, p. 106.
[d] Messages and Papers of the Presidents, **1**, pp. 83.

proposition had been made to the French and British Governments to obtain an international standard.[a] This report was accepted and the matter rested there, although Washington, on October 25, 1791, repeated his former recommendations in his third annual message to Congress, in the following language:[b]

> A uniformity in the weights and measures of the country is among the important objects submitted to you by the Constitution and if it can be derived from a standard at once invariable and universal, must be no less honorable to the public councils than conducive to the public convenience.

A week later the Senate appointed a committee to take into consideration the subject of weights and measures. The committee reported on the 4th of April, 1792, recommending the adoption of the second plan proposed by Jefferson, which was an entirely decimal system. Again no definite action was taken. The matter was considered in a desultory way by Congress from time to time, but no agreement was reached notwithstanding that the repeated recommendations of Washington were followed by those of Adams. A sufficient explanation for the disinclination of Congress to act in a matter of such admitted importance was the difficulty of agreeing upon a plan.

The Fifth Congress, second session, in 1799, passed an act ordering that the surveyor (of each port of the United States) shall from time to time, and particularly on the first Monday of January and July in each year, examine and try the weights, measures, and other instruments used in ascertaining the duties on imports with standards to be provided by each collector at the public expense for that purpose; and when disagreements and errors are discovered he shall report the same to the collector and obey and execute such directions as he may receive for the correction thereof agreeably to the standards aforesaid.[c]

This was the first act passed by Congress in regard to weights and measures, but in view of the fact that no standards had ever been adopted the legislation was not put into operation until about thirty-five years after its passage, when certain standards, which will be referred to later, were adopted by the Treasury Department.

After the war of 1812 the question of uniformity in weights and measures was again brought to the attention of Congress, and in 1819 a committee of the House of Representatives proposed to adopt absolute standards conforming to the weights and measures in common use; to obtain through a commission copies of the yard, the bushel, the wine gallon, and the pound supposed to conform to those in common use in the United States; to preserve these standards and to dis-

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[a] Journal of the Senate, p. 143; John L. Fenno.
[b] Messages and Papers of the Presidents, **1**, p. 108.
[c] Statutes at Large, **1**, p. 643.

tribute copies of them; to compare the length measure with the length of the second's pendulum and also with that of an arc of the terrestrial meridian; to connect them by determining the weight of a certain bulk of distilled water, and to define the bushel and the gallon by the weight of water which they contain.[a] No further record of the report is found, and it may be assumed that no action upon it was taken. The Senate had, by a resolution adopted March 3, 1817—two years prior to the above report—requested the Secretary of State to prepare and report a "statement" relative to the regulations and standards for weights and measures in the several States and relative to the proceedings in foreign countries for establishing uniformity in weights and measures, together with such propositions relative thereto as might be proper to adopt in the United States.

John Quincy Adams was at that time Secretary of State, and four years later—namely, on February 22, 1821—he submitted an elaborate report to the House of Representatives, in which, among other recommendations, the following are found:

(1) To fix the standard with the partial uniformity of which it is susceptible for the present, excluding all innovations.

(2) To consult with foreign nations for the future and ultimate establishment of universal and permanent uniformity.

As before, Congress took no action, probably because the situation at that time was extremely complicated. Neither the metric system in France nor the system in common use in England was well established. In France the law making the metric system compulsory had been repealed, and the metric system was in use side by side with the ancient weights and measures, thus producing endless confusion. In England the situation was not much better; the ale gallon of 282 cubic inches and the wine gallon of 231 cubic inches were both in use until 1824, when the new imperial gallon, containing 10 pounds of water, and of a capacity of about 277¼ cubic inches, was adopted, together with the bushel of 8 gallons. Neither of these measures was in use in this country, and hence the United States could not at that time adopt either the system in use in England or the one in France without introducing radical changes in the weights and measures already in use, nor was there at that time any positive assurance that either the English or the metric system would be permanent.

While Congress had been considering the matter, most of the States had, independently of one another, secured and adopted standards. Most of the standards thus adopted were brought from England; nevertheless, standards of the same denomination differed widely

[a] Executive Doc. No. 73, 30th Cong., 1st sess., Senate.

among themselves, thus perpetuating confusion in the commerce between adjacent States.

Though confusion in commercial transactions might be overlooked, uncertainty in regard to the coinage could not be tolerated, and on May 19, 1828, a certain troy pound was adopted as the standard for coinage by Congress in an "Act to continue the Mint at the City of Philadelphia, and for other purposes." The section 2 of the act referred to reads as follows:

And be it further enacted, That, for the purpose of securing a due conformity in weight of the coins of the United States * * * the brass troy pound weight procured by the minister of the United States at London, in the year one thousand eight hundred and twenty-seven, for the use of the mint, and now in the custody of the Mint at Philadelphia, shall be the standard troy pound of the Mint of the United States, conformably to which the coinage thereof shall be regulated.

The troy pound thus adopted had been procured in the year 1827 by Albert Gallatin, minister of the United States at London, and brought to this country by special messenger, who delivered it to the director of the Mint at Philadelphia. The weight was of brass and an exact copy of the imperial troy pound of Great Britain, according to the statement of Captain Kater, who made the comparison between the two standards. The casket and accompanying packages were retained under seal until Mr. Adams, President of the United States, visited Philadelphia and verified the seal of Mr. Gallatin and the other facts in regard to its authenticity.

This ceremony took place on October 12, 1827, and the full certificate of President Adams in regard to the seal, which he readily recognized, and to the whole transaction and consequent accuracy of the weight was added to the vouchers in the case. He declared, in conclusion, his belief that the brass weight then exhibited was the identical pound copy of the imperial standard troy pound of Great Britain referred to in the aforesaid certificates.[a] The foregoing facts were communicated to Congress through the Committee on the Mint and resulted in the passage of the act cited above.

While the act of Congress of 1828 only made this pound the standard for coinage, it virtually became the fundamental standard of the United States from which the avoirdupois pound in common use was derived.

On May 29, 1830, two years after the mint pound had been legalized for coinage, the Senate passed a resolution directing the Secretary of the Treasury to cause a comparison of the weights and measures in use at the principal custom-houses to be made, and to report to the Senate at its next session.

[a] Report on Weights and Measures, Franklin Institute, 1834, Appendix No. VII.

Steps were promptly taken by the Treasury Department to comply with the resolution of the Senate, and the preliminary report of F. R. Hassler, Superintendent of the Coast Survey, to whom the investigation had been intrusted, was transmitted to the Senate on March 3, 1831,[a] this being followed by a more complete report in June, 1832.

As was anticipated, large discrepancies were found to exist among the weights and measures in use at the different ports, some being too small and others too large, but the average value of the various denominations agreed fairly well with the weights and measures in use in Great Britain at the time of the American Revolution.

Without waiting for authority from Congress the Treasury Department took immediate steps to correct the evil by having constructed, under the direction of Mr. Hassler, the necessary weights and measures for the customs service. The divergencies among the weights and measures in use in the customs service were directly opposed to the spirit of the Constitution, which requires that all duties, imposts, and excises shall be uniform throughout the United States,[b] and the Secretary of the Treasury felt fully authorized in taking steps to secure uniformity when discrepancies were once known to exist.

Before weights and measures could be constructed, however, it was necessary for the Treasury Department to determine upon certain units and to adopt material representatives of these units. Those finally adopted were the yard of 36 inches, the avoirdupois pound of 7,000 grains, the gallon of 231 cubic inches, and the bushel of 2,150.42 cubic inches. The standard yard adopted was the 36 inches comprised between the twenty-seventh and the sixty-third inches of a certain 82-inch brass bar, prepared for the Coast Survey by Troughton, of London. This bar had been brought to the United States by Hassler in 1813, and the 36-inch space referred to was supposed to be identical with the English standard at 62° F., though it had never been directly compared with that standard.

It is evident from the reports of Mr. Hassler that he regarded the English yard as the real standard of length of the United States and the Troughton scale merely as a copy whose length should be corrected if it was subsequently found to differ from the English yard; and this view was taken by those who subsequently had charge of our standards, as will be shown later on.

The avoirdupois pound adopted by Mr. Hassler as the standard for the Treasury Department was derived from the troy pound of the mint according to the equivalent, 1 avoirdupois pound equals $\frac{7000}{5760}$

[a] See H. R. Doc. No. 299, 22d Cong., 1st sess.

[b] Sec. VIII, clause 1.

pounds troy. This was the accepted relation in this country as well as in England; hence both the troy and avoirdupois pounds adopted were in practical accord with the similar standards of Great Britain.

CAPACITY STANDARDS.

The units of capacity, namely, the wine gallon of 231 cubic inches and the Winchester bushel of 2,150.42, were adopted, because, as intimated, they represented more closely than any other English standards the average of the capacity measures in use in the United States at the date of Mr. Hassler's investigation. The wine gallon was introduced as a wine measure into England in 1707, during the reign of Queen Anne, but it was abolished in 1824, when the new imperial gallon, containing 10 pounds of water, was made the standard. This last statement applies also to the bushel of 2,150.42 cubic inches. This bushel is the earliest English capacity measure of which we have any record, a copy of it made by order of Henry VII being still in existence. But this bushel had also been abolished in England, it having been superseded by the bushel of 8 imperial gallons. Therefore neither the gallon nor the bushel adopted by the United States Treasury Department was in accord with the legal capacity standards of England, but they were smaller by about 17 per cent and 3 per cent, respectively, and these differences exist at the present time. Not only did they differ from the new standards in Great Britain, but they also differed from the discarded English standards from which they were derived for the reason that Mr. Hassler selected the temperature of the maximum density of water, namely, 39.2° F.[a] as the temperature at which the United States measures were standard, whereas their English prototypes were standard at 62° F.

Such, then, were the fundamental standards adopted upon the recommendation of Mr. Hassler by the United States Treasury Department, and to which the weights and measures for the customs service were made to conform. The construction of the weights and measures for this purpose was pushed with almost feverish haste, and so well satisfied was Congress with the progress made that the following resolution was passed and approved June 14, 1836:

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and he hereby is, directed to cause a complete set of all weights and measures adopted as standards and now either made or in progress of manufacture for the use of the several custom-houses,

[a] According to the determination made by Mr. Hassler on the expansion of water, 39.83° F. was the temperature of maximum density. See report of Alexander D. Bache, Superintendent of Weights and Measures, 46–47. Ex. Doc. No. 73, 30th Cong., 1st sess.

and for other purposes, to be delivered to the governor of each State in the Union, or such person as he may appoint for the use of the States, respectively, to the end that a uniform standard of weights and measures may be established throughout the United States.

While the act does not specifically adopt the standards above described, the practical effect of it was to make them the standards for the United States, inasmuch as the weights distributed to the States in accordance with the act were in almost every case adopted by the State legislatures soon after their receipt.

The act of 1836 was supplemented in 1838 by a joint resolution of Congress, which directed the Secretary of the Treasury to furnish balances to the States. By 1838 the weights for the States were reported finished, and during the following year the weights for the custom-houses were completed and delivered.[a]

By 1850 practically all the States admitted to the Union had been supplied with complete sets of weights and measures, and in addition sets were presented to England, France, Japan, and Siam. As new States were admitted they were also supplied with sets of standards, the last set being supplied to North Dakota in 1893.

In order to carry out the provisions of the acts of 1836 and 1838 the Office of Weights and Measures, under the direction of the Superintendent of the Coast Survey, had been established, and all the standards adopted at the beginning of the work, and subsequently, were in charge of this Office, with the exception of the troy pound of the mint, which has always remained at Philadelphia.

In October, 1834, the British imperial yard and troy pound made in 1758, of which the Troughton scale and the mint pound were supposed to be exact copies, were destroyed by the burning of the Houses of Parliament. When the new imperial standards to replace them were completed in 1855 two copies of the yard and one copy of the avoirdupois pound were presented to the United States, arriving in this country in 1856. One of these bars, namely, bronze yard No. 11, was very soon after compared with the Troughton scale, the result showing that the accepted 36 inches of the Troughton scale was 0.00087 inch longer than the British imperial yard.[b] The second bar received from England was subsequently compared with the Troughton scale and fully corroborated the result obtained from the comparison with bronze No. 11. The new yards, and especially bronze No. 11, were far superior to the Troughton scale as standards of

[a] H. R. Doc. 159, 28th Cong., 2d sess.

[b] See Report of the Secretary of the Treasury on the construction and distribution of weights and measures in 1857. S. Doc. No. 27, 34th Cong., 3d sess.

length, and consequently they were accepted by the Office of Weights and Measures as the standards of the United States, and all comparisons were afterwards referred to the imperial yard through these two standards. They were twice taken to England and recompared with the imperial yard, once in 1876 and again in 1888.

The avoirdupois pound presented with the two yards was also compared with the United States avoirdupois pound derived from the mint pound, the result showing a very satisfactory agreement. The advent of the new pound did not, therefore, disturb the position of the troy pound of the mint or of the avoirdupois pound derived from the mint pound.

METRIC SYSTEM.

The next and perhaps the most important legislation enacted by Congress was the act of 1866 legalizing the metric system of weights and measures in the United States. The act, which was passed July 28, 1866, reads as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the passage of this act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system, and no contract or dealing or pleading in any court shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 2. *And be it further enacted,* That the tables in the schedule hereto annexed shall be recognized in the construction of contracts and in all legal proceedings as establishing in terms of the weights and measures now in use in the United States the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system.

MEASURES OF LENGTH.

Metric denominations and values.		Equivalents in denominations in use.
Myriameter	10,000 meters.	6.2137 miles.
Kilometer	1,000 meters.	0.62137 miles, or 3,280 feet and 10 inches.
Hectometer	100 meters.	328 feet and 1 inch.
Dekameter	10 meters.	393.7 inches.
Meter	1 meter.	39.37 inches.
Decimeter	$\frac{1}{10}$ of a meter.	3.937 inches.
Centimeter	$\frac{1}{100}$ of a meter.	0.3937 inch.
Millimeter	$\frac{1}{1000}$ of a meter.	0.0394 inch.

MEASURES OF CAPACITY.

Metric denominations and values.			Equivalents in denominations in use.	
Names.	Number of liters.	Cubic measure.	Dry measure.	Liquid or wine measure.
Kiloliter or stere.	1,000	1 cubic meter	1.308 cubic yards.	264.17 gallons.
Hectoliter	100	$\frac{1}{10}$ of a cubic meter	2 bushels and 3.35 pecks.	26.417 gallons.
Dekaliter	10	10 cubic decimeters.	9.08 quarts	2.6417 gallons.
Liter	1	1 cubic decimeter	0.908 quart	1.0567 quarts.
Deciliter	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic decimeter.	6.1022 cubic inch.	0.845 gill.
Centiliter	$\frac{1}{100}$	10 cubic centimeters	0.6102 cubic inch.	0.338 fluidounce.
Milliliter	$\frac{1}{1000}$	1 cubic centimeter	0.061 cubic inch.	0.27 fluid dram.

MEASURES OF SURFACE.

Metric denominations and values.		Equivalents in denominations in use.
Hectare	10,000 square meters.	2.471 acres.
Are	100 square meters.	119.6 square yards.
Centare	1 square meter.	1,550 square inches.

WEIGHTS.

Metric denominations and values.			Equivalents in denominations in use.
Names.	Number of grams.	Weight of what quantity of water at maximum density.	Avoirdupois weight.
Millier or tonneau	1,000,000	1 cubic meter	2204.6 pounds.
Quintal	100,000	1 hectoliter	220.46 pounds.
Myriagram	10,000	10 liters	22.046 pounds.
Kilogram or kilo	1,000	1 liter	2.2046 pounds.
Hectogram	100	1 deciliter	3.5274 ounces.
Dekagram	10	10 cubic centimeters	0.3527 ounces.
Gram	1	1 cubic centimeter	15.432 grains.
Decigram	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic centimeter	1.5432 grains.
Centigram	$\frac{1}{100}$	10 cubic millimeters	0.1543 grain.
Milligram	$\frac{1}{1000}$	1 cubic millimeter	0.0154 grain.

While the above act was being considered, Congress also considered a resolution authorizing the Secretary of the Treasury to furnish the States with metric weights and measures. Strange to say, this resolution, which logically should follow, was approved one day before the act legalizing the use of the metric system. It was a joint resolution and read as follows:

Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and he is hereby, authorized and directed to furnish to each State, to be delivered to the governor thereof, one set of standard weights and measures of the metric system for the use of the States, respectively.

The work of making and adjusting these standards fell, naturally, upon the Office of Weights and Measures, and the first question that had to be considered was that of standards. The practice followed by other countries which had adopted the metric system of accepting the meter and the kilogram of the archives of France as fundamental standards was followed by the United States. The question was mainly one of securing authentic copies of these standards. Fortunately the Office of Weights and Measures had several copies of both standards of more or less authenticity on hand, but without hesitation an iron bar, known as the "committee meter," and a platinum kilogram, known as the "Arago kilogram," were selected.

COMMITTEE METER.

The committee meter is one of fifteen similar bars, whose lengths were ascertained in the process of constructing the original meter by the French committee of weights and measures in 1799; hence its name, "committee meter."

The committee referred to was composed of members of the National Institute of France and of deputies from foreign countries. Mr. J. G. Tralle, the deputy from the Helvetic Republic, had been placed in charge of the construction of the meters, and when the bars were distributed among the members of the committee he secured two of them, one of which he presented to Mr. Hassler. This bar was therefore of the highest authenticity. As before stated, it is made of iron, with a cross section of 9 by 29 mm, and its length is defined by the end surfaces, which are remarkably plane when one considers the age in which the bars were made. The bar bears the stamp of the committee, namely, a small ellipse, whereof three quadrants are shaded and the fourth one clear, except for the number 10,000,000, which indicates the number of meters in a meridian quadrant of the earth. It also bears the mark :· at one end, by which it was distinguished during the comparison with the other meters. In Mr. Hassler's report on the

construction of the meters[a] it is stated, on the authority of Mr. Tralle, that all the meters agreed with the true meter within one-millionth part of the toise.[b]

When Mr. Hassler came to the United States in 1805 he brought with him the committee meter, which he soon after presented to the Philosophical Society of Philadelphia, Pa. Shortly after, when he was put in charge of the survey of the coast, the meter was placed at his disposal by the Philosophical Society, and he made it the standard of length for that work, and until 1890 all base measurements of the Survey were referred to this meter.[c]

In view of the foregoing, it was but natural that this bar should be selected as the standard to which the State meters should conform.

ARAGO PLATINUM KILOGRAM.

The Arago kilogram was procured in 1821 by Mr. Gallatin while minister of the United States to France and was sent to this country, together with a platinum meter. The certificate of Arago, the celebrated physicist, which accompanied these standards, states that the kilogram differs from the original kilogram des Archives by less than 1 mg. The weight is a platinum cylinder with flat bases, the edges being slightly rounded. The height and diameter are nearly equal, being approximately 39.5 mm each. There is no stamp or distinguishing mark of any kind, except near the center of one base there is a faint lathe or tool mark of circular form, thus: ⊙. The weight is contained in a square mahogany box, on the cover of which is a circular silver plate bearing the inscription "Kilogramme comparé pour son Poids a l'Etalon Prototype des Archives de France, et verifié par M. Arago. Fortin fecit." No particulars of Arago's comparison with the kilogram des Archives were furnished, and consequently it is not known what means were used by him in making his comparison nor whether he reduced his weighings to vacuo. It was not until 1879 that the Arago kilogram was compared with any other standards of recognized authority. It is true that it was compared between 1852 and 1873 with a couple of kilograms in the possession of the Office of Weights and Measures, but as both of these weights were of brass and of unknown density, no great reliance could be attached to the results. In 1879, however, it was taken to England and there compared with the British platinum kilogram in the custody of the Standards Office.

[a] H. R. Doc. No. 299, 22d Cong., 1st sess., pp. 75, 76.

[b] The toise was the French standard of length prior to the adoption of the meter, and all the geodetic measurements upon which the meter was based were made with the toise. Its length is 1.949+ meters.

[c] Special Publication No. 4, U. S. Coast and Geodetic Survey.

FIG. 1.—THE SILBERMANN KILOGRAM.

This comparison indicated that the Arago kilogram was 4.25 mg light, but this result could not be considered conclusive, on account of certain assumptions made in the reduction to vacuo and also in regard to the correction to the British kilogram.

In 1884 the weight was taken from the Standards Office in London, where it had been since 1879, to the International Bureau of Weights and Measures at Paris and there compared with two auxiliary kilograms whose values in terms of the kilogram of the Archives were known with the greatest accuracy. The results obtained from the comparison confirmed that previously obtained from the comparison with the British kilogram, the result giving

$$\mathfrak{K}_a = 1{,}000\ \text{g} - 4.63\ \text{mg}$$

As the weights supplied to the States were to be made of brass, it was more convenient to compare them with a brass standard, and in order to do this two secondary brass standards were carefully compared between the years 1873–1876 with the Arago kilogram and afterwards used in all the work of adjustment and verification. One of the kilograms, known as the Silbermann kilogram, was presented to the United States by France in 1852, together with a number of other weights and measures. The other kilogram used was one made in the Office of Weights and Measures and was identical in form and material with the kilograms subsequently furnished to the States.

The unit of capacity in the metric system being defined as the volume of the mass of 1 kilogram of pure water at the temperature of maximum density, the most convenient way to adjust such measures, and in fact all capacity measures, is by weighing the water they contain. The only two material standards that need to be considered, therefore, in connection with the metric weights and measures furnished to the States in accordance with the act of 1866 are the committee meter and the Arago kilogram described above.

By the end of 1880 practically all the States had been supplied with sets of metric weights and measures consisting of the following denominations:

Length measures	One brass-line meter. One steel-end meter.
Capacity measures	One liter made of brass. One decaliter made of brass.
Weights	One myriagram made of brass. One kilogram made of brass. One ½ kilogram made of brass. One gram made of brass. One set of small silver weights from 4 decigrams to 1 milligram.

It is necessary at this point to go back a few years and give an account of the establishment of the International Bureau of Weights and Measures, since the present fundamental standards of length and mass for practically the whole civilized world result from the establishment of that institution.

In reponse to an invitation of the French Government, the following countries sent representatives to a conference held in Paris on August 8, 1870, to consider the advisability of constructing new metric standards:

Austria,	Italy,	Spain,
Ecuador,	Norway,	Switzerland,
France,	Peru,	Turkey,
Great Britain,	Portugal,	United States,
Greece,	Russia,	Colombia,

in all 15 countries. This conference was of short duration, on account of the war then raging between France and Germany.

A second conference was held two years later, at which 30 countries were represented, the United States again being among this number. At this conference it was decided that new meters and new kilograms should be constructed to conform with the original standards of the Archives, and a permanent committee was appointed to carry out this decision. The preparation of the new standards had advanced so far by 1875 that the permanent committee appointed by the conference of 1872 requested the French Government to call a diplomatic conference at Paris to consider whether the means and appliances for the final verification of the new meters and kilograms should be provided, with a view to permanence, or whether the work should be regarded as a temporary operation.

In compliance with this request a conference was held in March, 1875, at which 19 countries were represented, the United States as usual being of this number.

On May 20, 1875, 17 of the 19 countries represented signed a convention which provided for the establishment and maintenance of a permanent International Bureau of Weights and Measures to be situated near Paris and to be under the control of an international committee elected by the conference, the committee to consist of 14 members, all belonging to different countries.

In addition to the primary work of verifying the new metric standards the bureau was charged with certain duties, the following being the most important:

(1) The custody and preservation, when, completed of the international prototypes and auxiliary instruments.

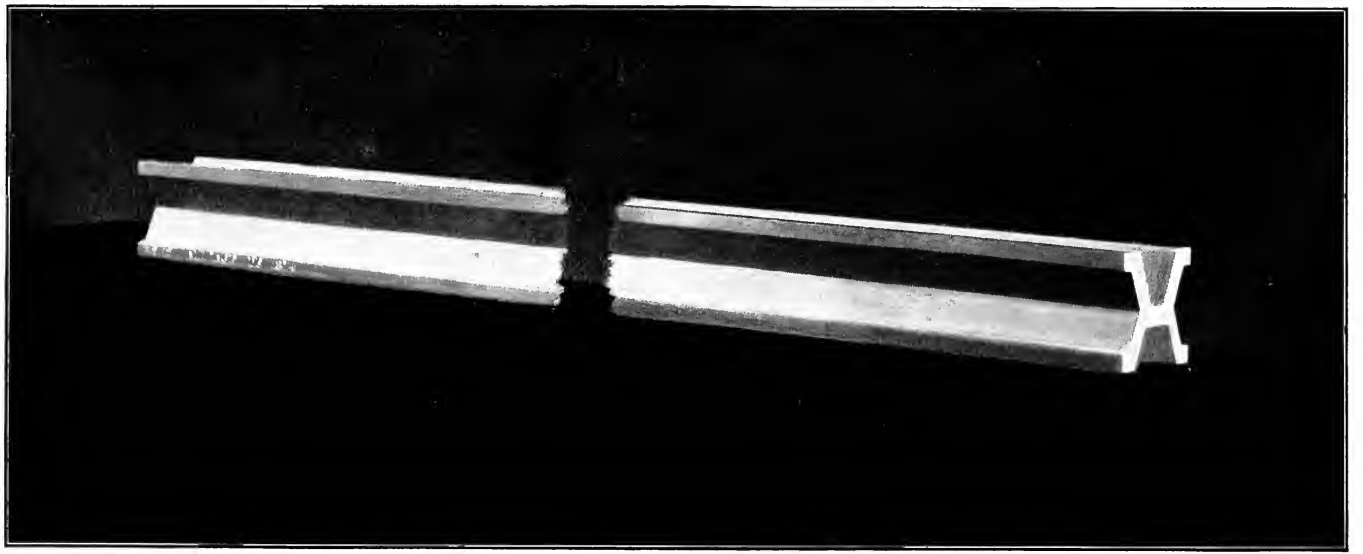

FIG. 2.—THE UNITED STATES PROTOTYPE METER.

FIG. 3.—THE UNITED STATES PROTOTYPE KILOGRAM.

(2) The future periodic comparison of the several national standards with the international prototypes.

(3) The comparison of metric standards with standards of other countries.

The expenses of the bureau were to be defrayed by contributions of the contracting Governments, the amount for each country depending upon the population and upon the extent that the metric system was in use in the particular country.

In accordance with the terms of the convention the French Government set aside a plat of ground in the park of St. Cloud just outside of Paris, and upon this ground, which was declared neutral territory, the International Bureau of Weights and Measures was established.

The construction of the meters and kilograms had been intrusted to a special committee, and early in 1887 the committee completed its work and the new meters and kilograms were turned over to the International Bureau for comparison with the standards of the Archives and with one another.

It had been decided as early as 1873 that the new standards should be made of an alloy of 90 per cent platinum and 10 per cent iridium, and that the meters should be line standards of the cross section shown in the illustration. Altogether 31 meters and 40 kilograms were constructed. By 1889 the entire work was completed and in September of that year a general conference was held at Paris, and by it the work of the international committee was approved.

The meter and kilogram which agreed most closely with the meter and kilogram of the Archives were declared to be the international meter and the international kilogram. These two standards, with certain other meters and kilograms, were deposited in a subterranean vault under one of the buildings of the International Bureau, where they are only accessible when three independent officials with different keys are present. The other standards were distributed by lot to the various Governments contributing to the support of the International Bureau. Those falling to the United States were meters Nos. 21 and 27 and kilograms Nos. 4 and 20.

Meter No. 27 and kilogram No. 20 were brought under seal to this country by Mr. George Davidson, of the Coast and Geodetic Survey, and on January 2, 1890, they were opened at the White House and accepted by President Harrison, who certified that they were received in good condition, and that he confidently believed that they were the standards referred to in the report. The other two standards were received the following July and were deposited in the Office of Weights and Measures, where those accepted as national standards

by the President had already been taken.[a] On April 5, 1893, the Superintendent of Weights and Measures, with the approval of the Secretary of the Treasury, decided that the international meter and kilogram would in the future be regarded as the fundamental standards of length and mass in the United States, both for metric and customary weights and measures.

This action did not in any way affect the metric weights and measures of the United States inasmuch as the meter and kilogram of the Archives had always been regarded as our fundamental metric standards, and the international meter and kilogram had identical values so far as could be determined by the most refined measurements.

The effect of this decision on the customary weights and measures also left them practically undisturbed. All comparisons made immediately prior to 1893 indicated that the relation of the yard to the meter fixed by the act of 1866[b] was by chance the exact relation between the international meter and the British imperial yard within the error of observation. A subsequent comparison made between the standards just mentioned indicates that the legal relation adopted by Congress is in error by one ten-thousandth of an inch; but in view of the fact that certain comparisons made by the English Standards Office between the imperial yard and its authentic copies show variations as great, if not greater than this, it can not be said with certainty that there is a difference between the imperial yard of Great Britain and the United States yard derived from the meter.

The case of the pound was slightly different, inasmuch as the relation of the kilogram to the pound, fixed by the act of 1866, was only approximate. In the act mentioned the kilogram was stated to be equal to 2.2046 pounds avoirdupois; but as 2.204622 was known to be a more precise value, and since it did not conflict with the legal value the avoirdupois pound was declared to be equal to $\frac{1}{2.204622}$ kilograms.

Neither the troy pound of the mint nor the copies of the imperial yard in the possession of the Office of Weights and Measures were satisfactory standards. The mint pound is made in two pieces, the knob being screwed into the body; hence its density can not be determined by weighing in water on account of danger of leakage. Moreover, it is made of brass not plated, and therefore liable to alteration by oxidation.

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[a] Upon the establishment of the Bureau of Standards on July 1, 1901, all standards and other property in possession of the Office of Weights and Measures passed under the control of the Bureau.

[b] The value of the yard, in accordance with the above declaration, is 1 yard$=\frac{3600}{3937}$ meter.

The bronze yard No. 11, which was an exact copy of the British imperial yard both in form and material, had shown changes when compared with the imperial yard in 1876 and 1888 which could not reasonably be said to be entirely due to changes in No. 11. Suspicion as to the constancy of the length of the British standard was therefore aroused.

On the other hand, the new meters and kilograms represented the most advanced ideas of standards, and it therefore seemed that greater stability in our weights and measures as well as higher accuracy would be secured by accepting the international meter and kilogram as fundamental standards.

Time has amply proved the wisdom of this action, and therefore when the Bureau of Standards was established in July, 1901, the decision made by the Office of Weights and Measures in 1893 to adopt the meter and kilogram as fundamental standards was fully accepted by this Bureau.

In conclusion I wish to state that in preparing so brief an account of so great a subject many matters of importance and interest have necessarily been omitted, but if I have succeeded in giving you an outline of the growth of our weights and measures, I shall have accomplished all that I had in mind when this paper was prepared.


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